CHAPTER 33

STARGOOSE BERRY

(*Phyllanthus acidus* Skeels)

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CONTENTS

1. INTRODUCTION

Stargoose berry (*Phyllanthus acidus* Skeels) is a tropical plant which generally planted in ornamental gardens for its attractive foliage. It is a semi-deciduous tree or ornamental shrub, 2 – 9 m height, with spreading, dense; bushy crown of thickish, rough, main branches, in general aspect resembling the Bilimbi. The wood of the plant is light-brown, fine-grained, attractive, fairly hard, strong, tough, durable if seasoned. It is one of the trees with edible small yellow berries fruits in the *Phyllanthaceae* family (Devi and Paul, 2011). It has limited consumption as fresh fruit or minimally processed products like chutney however, quality pickle is prepared from this fruit. Majumdar (2004) reported pectin content in the fruits and prepared a tangy jelly from the pulp of stargoose berry fruit by addition of high amount of sugar. In Indonesia, the tart flesh is added to many dishes as a flavoring agent. The juice is used in cold drinks in the Philippines. Bahamian cooks soak the whole fruits in salty water overnight to reduce the acidity, then rinse, boil once or twice, discarding the water, then boil with equal amount of sugar until thick, and put up in sterilized jars without removing seeds. Fully ripe fruits do not really require this treatment. If cooked long enough with plenty of sugar, the fruit and juice turn ruby-red and yield a sprightly Jetty. It is also combined with other fruits in making chutney

and jam because it helps these products to set. Often, the fruits are candied, or pickled in salt. In Philippines, they are used to make vinegar. The young leaves are cooked as greens in India and Indonesia.

In India, the root bark has high medicinal value. The fruits are taken as liver tonic and to enrich the blood. The syrup is prescribed as a stomachic; and the seeds are cathartic. The leaves, with added pepper, are poultice on sciatica, lumbago or rheumatism. A decoction of the leaves is given as a sudorific. Because of the mucilaginous nature of the leaves, they are taken as a demulcent in cases of gonorrhea in India. In Malaya, the root is drastically purgative and regarded as toxic but is boiled and inhales the steam to relieve coughs and headache. To alleviate asthma, the root infusion is taken in very small doses. Externally, the root is used to treat psoriasis of the soles of feet. The juice of the root bark, which contains saponin, gallic acid, tannin and a crystalline substance which may be lupeol, has been employed in criminal poisoning. The acrid latex of various parts of the tree is emetic and purgative.

In an study conducted by Umander *et al.* (1990), concluded that *Phyllanthus atnarus* and other closely related species appear to contain activity against the endogenous DNAP of 'hepadna viruses'. This may be the basis for traditional uses of these species against disease symptoms like jaundice which retrospectively could, (in at least some cases), have been caused by hepatitis B virus. They also concluded that the DNAP inhibitory activity is least affected by soil and growing conditions but plant genetic makeup has greater roll in active principles content.

2. DOMESTICATION

Phyllanthus acidus is found throughout Asia and also in the Caribbean region, Central and South America (Janick and Paull, 2008). The species was carried out to East Indies including Philippines from prehistoric times where it is being cultivated in scattered pockets (Morton *et al*., 1987). It is also more commonly cultivated in Southeast Asian countries (Devi and Paul, 2011). In India, *P. acidus* has been found to grow wild as well under home garden as in Southern and Eastern regions including Bihar and Uttar Pradesh and North east region (Mazumdar, 2004; Devi and Paul, 2011).

3. TAXONOMY

The genus *Phyllanthus* belonging to family Euphorbiaceae, derived from Greek words meaning leaf-flower, an allusion to the apparent bearing of flowers on the leaves. It is an important group of fruit and medicinal plants used for various purposes (Rout *et al*., 2010). Star gooseberry (*Phyllanthus acidus* Skeels, *syns.Pdistichus* Mue l l. Arg.; *Cicca acida* Merr.; *C.disticha* L., *Averrhoa* acidaLinn., *Cicca acidissima* Blanco, *Phyllanthus distichus MuelL-Arg.* and *Phyllanthus acidissimus MuelL-Arg.*) is important member of family Euphorbiaclae. The scientific classification of stargoose berry is given below (Devi and Paul, 2011);

Classification of the plant

Kingdom	:	Plantae
Division	:	Mgnoliophyta
Class	:	Mgnoliopsida
Order	:	Mglgiphiales
Family	:	Phyllanthaceae
Tribe	:	Phyllanthaceae
Subtribe	:	Flueggeinae
Genus	:	Phyllanthus
Species	:	*Phyllanthus acidus*.

4. CENTERS OF ORIGIN/CENTERS OF DIVERSITY

It is native of Indo-Chinese-Indonesian Centre of diversity more precisely to India (Zeven and Zhukosky, 1975). Madagaskar is believed to be second home of stargoose berry. Furthermore, Mazumdar (2004) mentioned that India is the natural home of stargoose berry where it grows as wild in Southern and Eastern regions including Bihar and Uttar Pradesh. The other opinion says that the species is originated in Madagascar (Devi and Paul, 2011) and have been carried to East Indies including Philippines where it is being cultivated in scattered pockets from prehistoric times (Morton *et al*., 1987).

Phyllanthus acidus is more commonly grown in Indonesia, South Vietnam and Laos, and frequently in northern Malaya, and in India in home gardens (Devi and Paul, 2011). It grows in India's tropical regions, from Kerala in the south to Manipur in the far northeast. The fruit is favoured by children in Guam where it is very familiar, and also occurs in Hawaii and some other Pacific Islands. It was introduced into Jamaica from Timor in 1793 and has been casually spread throughout the Caribbean islands and to the Bahamas and Bermuda. It has long been naturalized in southern Mexico and the lowlands of Central America and is occasionally grown in Colombia Venezuela Surinam, Peru and Brazil. Formerly an escape from cultivation in South Florida, there are now only scattered specimens remaining here as curiosities. The tree prefers hot, humid tropical low land up to 1000 m altitude (Morton *et al*., 1987; Devi and Paul, 2011).

5. OBJECTIVES OF IMPROVEMENT

The major breeding objectives in stargoose berry is to evolve cultivar of dwarf stature trees with precocity in bearing, high yielding, good fruit quality with large fruit size, good shelf-life, seedlessness and less sour fruit.

6. CYTOGENETIC

The basic chromosome number of *Phyllanthus acidus* (L.) Skeels is 2n = 28 (Zeven and Zhukosky, 1975).

7. INHERITANCE PATTERN

There is no report available on inheritance pattern of stargoose berry.

8. PROBLEM IN BREEDING

Breeding work in this crop has been very limited, which might be to the non-popularity of the crop with limited consumption of its fresh fruits. Certain problems related to breeding are monoecious (Bullock, 1985) and protogynous (Subba Reddi and Reddi, 1982) nature of the tree. Furthermore, flowers are small and male flowers are pendent resulting in no secondary landing of pollen within the flower.

9. FLORAL BIOLOGY

9.1. Flower

Flowers are tiny and pinkish of male, female and some hermaphrodite flowers. Flowers are 4-parted and rosy. It is borne in clusters in panicles 5-12.5 cm long, hanging directly from leafless lengths of the main branches, or directly from trunk. Flowers are monoecious (Bullock, 1985), markedly protogynous (Subba Reddi and Reddi, 1982). They are mostly borne in inflorescence and less frequently in leaf axils. The inflorescence is racemose, cauliflorous borne on spur-shoots on older wood. Frequency of male and female flowers varies with inflorescence. Subba Reddi and Reddi (1984) reported that the sex distribution in 1001 inflorescence, 85% inflorescence carrying both male and female, 8% only male and 7% only female flowers. Leaf axils produced male flowers but very rarely female flowers.

Female flower open first and stigma receptivity last for a prolonged period so that wastage of stigmas is minimised. It showed asynchronous flowering between individuals and between populations which might have been the evolutionary force for fixing the timing of pollen release to achieve maximum pollination (Subba Reddi and Reddi, 1982). Staminate flowers are small, pinkish to rusty red, sometimes greenish, pendent with slender pedicels of 2.3 – 2.8 mm length. Stamens are free and recurved. Pistillate flowers occur mostly together with the male flowers ranging from zero to 3 at the point of occurrence. It is small, greenish with pedicels and longer than male flowers.

In southern India, star gooseberry trees bear fruit twice a year: first fruit during April to May and second in August to September. In other regions, fruit season occurs late from November to January. Though these two are the main seasons, however, the trees have a tendency to bear fruit sporadically throughout the year. Furthermore, according to Hayes (1970) that in Kodur region of South India, stargoose berry bears fruits throughout the year and in large number during January.

9.2. Anthesis and Dehiscence

Flowers begin to open slowly from 1000 hr onwards and are completely open by 1700 hr and drop off inflorescence the following day (1800 hr). The short and oblong anthers dehisce after flowers are fully open. Dehiscence occurs laterally starting from the base to tip. Majority of flowers anther dehiscence in synchronous, occurring between 2000 hr and 0200 hr and attains a peak during 2100 – 2200 hr. However, dehiscence time may vary within one hour if non-synchronous. Following anther dehiscence, pollen release occurs only on disturbance. Wind is the major disturbance agent to inflorescence leading to releasing of pollen. Similarly, there is no secondary landing of pollen within the flower since the male flowers are pendent. Each anther produced 2350 – 3140 number of pollen (Subba Reddi and Reddi, 1982).

9.3. Stigma Receptivity

Stigmatic surface continues to grow even after completion of anthesis, and reaches the maximum attainable size in a span of 31 – 33 hrs. Stigma receptivity varies from 72 – 96 hrs as indicates by the loss of viscidity and the onset of blackening of the stigma (Subba Reddi and Reddi, 1982).

9.4. Pollination

Under Indian conditions, pollination in stargoose berry is being carried out by wind (Subba Reddi and Reddi, 1984). Similarly, anemophilous is predominantly in the dioecious *Phyllanthus pinnatus*. However, ants and flies foraging for pollen or secretions of male and female flowers enhance the rate of cross-pollination which increased natural fruit-set in *P. pinnatus* (Reddi and Subba Reddi, 1985). Furthermore, *P. pinnatus* showed synchronous flowering utilising the rain as an environmental trigger through which individual plants in the entire population coordinate simultaneous flower production. Such synchronization brings appropriate genetic exchange and seed set. Geitonogamy and xenogamy mechanism produced 91% and 93% fruit-set respectively in stargoose berry.

9.5. Fruit

Fruit develop so densely that they form spectacular masses or turban-like. The fruit is oblate with 6 to 8 ribs, small (1-2.5 cm wide). It produces sour but edible fruits, which is pale-yellow to nearly white when fully ripe (Arora and Pandey, 1996; Mazamdar, 2004). Fruits are waxy, fleshy, crisp, juicy and highly acidic. Tightly embedded in the center is a hard, ribbed stone containing 4 to 6 seeds (Devi and Paul, 2011; Morton *et al*., 1987). The taste of the fruit flesh resembles a very sour gooseberry- (*Ribes uva-crispa*).

10. DIFFERENT SPECIES

Several lesser known relative species of gooseberry is known to exist in India include *Phyllanthus scabifolius, Phyllanthus reticulatus, Phyllanthus debilis, Phyllanthus urinaria,* and *Phyllanthus virgatus etc.* However, Amla (*Phyllanthus emblica)* is the best-known relative of stargooseberry. The other related species of stargoose berry are given in Table 1.

Table 1. Related species of stargooseberrys

Sl. No.	Species
1.	*Phyllanthus abnormis* Baill.
2.	*Phyllanthus acuminatus Vahl.* (Jamaican gooseberry tree)
3.	*Phyllanthus amarus* Schumacher
4.	*Phyllanthus angustifolius* (Sw.) Sw.
5.	*Phyllanthus arbuscula* (Sw.) J.F.Gmel.
6.	*Phyllanthus atropurpureus* Bojer
7.	*Phyllanthus brasiliensis* (Aubl.) Poir.
8.	*Phyllanthus caesiifolius* Petra Hoffm. & Cheek
9.	*Phyllanthus caroliniensis* Walt.
10.	*Phyllanthus cochinchinensis* (Lour.) Spreng.
11.	*Phyllanthus cuneifolius* (Britt.) Croizat
12.	*Phyllanthus debilis* Klein ex Willd.
13.	*Phyllanthus emblica* L. (Indian gooseberry)
14.	*Phyllanthus engleri* Pax.
15.	*Phyllanthus epiphyllanthus* L.
16.	*Phyllanthus ericoides* Torr.
17.	*Phyllanthus fluitans* (red root floater)
18.	*Phyllanthus fraternus* G.L.Webster
19.	*Phyllanthus gentryi* Webster
20.	*Phyllanthus grandifolius* L.
21.	*Phyllanthus haughtii* Croizat
22.	*Phyllanthus juglandifolius* Willd.
23.	*Phyllanthus lacunarius* F.Muell.
24.	*Phyllanthus liebmannianus* Muell.-Arg.
25.	*Phyllanthus maderaspatensis* L.
26.	*Phyllanthus microcladus* Muell.-Arg.
27.	*Phyllanthus mirabilis* Müll.Arg. (the only succulent species of this genus)
28.	*Phyllanthus muellerianus* (Kuntze) Exell.
29.	*Phyllanthus niruri* L. - Chancapiedra
30.	*Phyllanthus parvifolius* Buch.-Ham. ex D.Don
31.	*Phyllanthus piscatorum* Kunth
32.	*Phyllanthus pentaphyllus* C. Wright ex Griseb.
33.	*Phyllanthus polygonoides* Nutt. exSpreng.
34.	*Phyllanthus polyspermus* Shumach. & Thonn.
35.	*Phyllanthus profusus* N.E.Br.
36.	*Phyllanthus pseudocanami* Müll.Arg.

[Table Contd.

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Sl. No.	Species
37.	*Phyllanthus pudens* L.C. Wheeler
38.	*Phyllanthus pulcher* Wallich ex Muell.-Arg.
39.	*Phyllanthus reticulatus* Poir.
40.	*Phyllanthus saffordii* Merr.
41.	*Phyllanthus salviifolius* Kunth
42.	*Phyllanthus sepialis* Müll.Arg.
43.	*Phyllanthus stipulatus* (Raf.) G.L. Webster
44.	*Phyllanthus tenellus* Roxb.
45.	*Phyllanthus urinaria* L. (Chamber bitter)
46.	*Phyllanthu svirgatus* G.Forst.
47.	*Phyllanthus watsonii* A. Shaw

11. CROP IMPROVEMENT METHODS

11.1. Selection

Flowers are monoecious and protogynous, therefore reproduction followed inbreeding (geitonogamy) and outbreeding (Subba Reddi and Reddi, 1982; Bullock, 1985). Very little or no breeding programme has been initiated in stargoose berry. Evaluation of physico-chemical of fully matured stargoose berry fruits from wild plants of Southern West Bengal has been carried out by Madan and Mazumdar (1997), which reported 5.02 g fruit weight, 1.71 specific gravity, 1.5 cm stalk-stylar length, 2.83 per cent titratable acidity, 0.6-2.5 per cent sugars and vitamin C content of 6 mg/ l00 g edible pulp. The nutrient content of stargoose berry is further depicted in Table 2.

Table 2. Nutrient contents (100 g of edible portion)

Sl. No.	Nutrients	Amount
1	Moisture	91.9 g
2	Protein	0.155 g
3	Fat	0.52 g
4	Ash	0.8 g
5	Calcium	0.51 mg
6	Phosphorous	5.4 mg
7	Iron	17.9 mg
8	Carotene	3.25 mg
9	Thiamine	0.019 mg
10	Riboflavin	0.025 mg
11	Niacin	0.013 mg
12	Ascorbic acid	0.292 mg

Source: Devi and Paul (2011)

11.2. Biotechnology

Rout *et al*. (2010) investigated the relationships among twelve species of *Phyllanthus, viz., Phyllanthus* spp. Acc No. 1, *Phyllanthus reticulatus*, *Phyllanthus nivosus*, *Phyllanthus nivosus* varigata, *Phyllanthus acidus*, *Phyllanthus emblica*, *Phyllanthus flatarnus*, *Phyllanthus urinaria*, *Phyllanthus rotundifolius*, *Phyllanthus virgatus* and *Phyllanthus amarus* collected from India using molecular markers. They assessed 259 marker loci, out of which 249 were polymorphic revealing 96.13% polymorphism. Nei's similarity index varied for RAPD from 0.35 to 0.76 and for ISSR marker systems from 0.31 to 0.76. The phylogenetic tree obtained from both RAPD and ISSR markers grouped the 12 species into two groups: group I consisting of only one species *Phyllanthus angustifolius* (Sw.) Sw and group II with the rest of 11 species. They further found that these results were in compliance with notable morphological characterization. They concluded that a high variation among the species of *Phyllanthus* was observed, which will help to identify different *Phyllanthus* species.

12. VARIETIES

There are no varieties existing in this crop, except as genotypes available in various growing areas.

13. FUTURE PROSPECTS

In southern region of India, star gooseberry trees bear fruit almost throughout the year. Any breeding work on this aspect will help in extending the availability of fruit with high yielding and better quality. No works has been carried out on germplasm collection, characterization and conservation of genotypes existing in several part of the country. Develop of improved varieties to meet the consumer preference is also desire for the popularity and adoption of this crop. The breeding potential of stargooseberry is yet to be exploited and these could be the source of several desirable genes(s). Inheritance pattern or linking of several traits is totally a new aspect in this crop, which could help in early and direct selection of targeting traits. Mutation breeding can be incorporated into breeding programme to create variability in the cultivar for developing of desirable varieties. Application of modern tools like molecular and cytogenetic study is highly required at present to generate more information and to ease breeding programme in stargooseberry. In the present scenario of climate change, there is a need to prepare for an unexpected adverse conditions and this can be met only if the available gene pool and technology is fully utilized, especially the neglected crops such as stargooseberry.

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STARGOOSE BERRY (*Phyllanthus acidus* Skeels)

Flowering and fruit setting-1

Flowering and fruit setting-2

Ripe fruit of Phyllanthus acidus

Unripe fruit of phyllanthus acidus